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The following data are taken from the documents submitted by the Applicant.

Examination request made pursuant to §44, Pat. Act.

(54) **X-ray tube with electron trap**

(57) X-ray tube having a magnetic system surrounding the vacuum housing with the cathode and the anode for deflecting and focussing the electron beam on the beveled anode edge and an X-ray exit window located in the vacuum housing, where an X-ray-permeable protective plate of a good heat-conducting material capable of thermal loading and having a small backscatter coefficient, which is in good thermal contact with the vacuum housing, is placed inside at some distance in front of the X-ray exit window.

## Description

The invention relates to an X-ray tube having a magnetic system surrounding the vacuum housing with the cathode and the anode for deflecting and focusing the electron beam on the beveled anode edge and an X-ray exit window located in the vacuum housing.

In X-ray tubes in which the electron beam is magnetically deflected by the cathode located on the axis of the tube to the edge of the anode - in principle, this applies to all X-ray tubes on the basis of rotary piston tubes, but also to some types of rotary anode tubes - the electron beam, due to the geometry of the arrangement when conventional anodes with corresponding plate-like angle are used, strikes the anode surface at a relatively flat angle. This results in elevated backscatter of electrons, in particular in the direction of the X-ray exit window. The consequence is elevated thermal loading of this X-ray exit window. In order not to weaken the X-radiation unnecessarily, however, on the other side the window may have only a relatively small material thickness, for example, in embodiments of high-grade steel, about 0.2 mm. The window must then be vacuum-tight and should at the same time overcome the not inconsiderable thermal output of the electrons scattered by the anode in the direction of the window.

Remedying this by making the window thicker is not practical. The reduced flow of X-rays owing to the greater weakening in the X-ray exit window would have considerable disadvantages for emitter service life, since the reduced

X-ray flow due to the weakening in the window would have to be compensated for by a greater stream of electrons and a higher generator output.

The object of the invention therefore is to construct an X-ray tube, in particular a rotary piston tube, in such a way that the aforementioned problems with backscatter electrons and elevated loading of the X-ray exit window can be avoided.

To accomplish this object, according to the invention it is provided that an X-ray-permeable protective plate of a good heat-conducting material capable of thermal loading and having a small electron backscatter coefficient, which is in good thermal contact with the vacuum housing, is placed inside at some distance in front of the X-ray exit window.

This protective plate may consist - which considerably facilitates the selection of material - of a material that need not be capable of much mechanical load, since unlike the X-ray exit window itself, it need not separate the evacuated interior of the X-ray tube from the outside environment. In this respect, the protective plate is not mechanically loaded by elevated external pressure nor need it be vacuum-tight, since its only task is to capture the backscatter electrons with simultaneous only minimal weakening of the continuous X-radiation.

Beryllium is especially suitable as material for the protective plate but, because of toxicity and its other properties, it is very hard to machine. With particular advantage, therefore, the protective plate should consist of a glass-like carbon, so-called glass graphite, such as is available for example under the trade name Sigradur. This cross-linked graphite has very small X-ray absorption, since

it has a low atomic number and low density. At 3-mm thickness and 70 keV, there is a loss of only about 7% under continuous X-radiation and of only 4.7% with 2-mm material thickness.

This glass graphite has a high thermal capacity, up to about 3000°C under vacuum, is suitable for vacuum operation and also has sufficient thermal conductivity so that it is easily able to remove the heat arising due to backscatter electrons on the housing near the X-ray exit window, where it is attached in good thermal contact with the vacuum housing.

In refinement of the invention, the protective plate is to be connected with good heat conduction to the vacuum housing on only one side at the anode-side end, while at the free end, it may be bent inward in order to remove the backscatter electrons from the vacuum housing.

Although even in rotary anode tubes, with the cathode situated in the axis of rotation of the anode, due to areal striking of the electron beam on the anode plate edge, backscatter electrons occur in considerable number, additionally heavily burdening the small stationary window, here, in addition to the possibility of use of the protective plate according to the invention, further benefit may alternatively result from shifting the electron gun away from the axis of rotation of the system, so that the electron beam strikes substantially perpendicular to the anode edge.

The invention is therefore of special importance for rotary piston tubes with cathode and anode arranged stationary in a rotating vacuum housing provided with an annular surrounding window, in which the electron beam is

basically deflected from the cathode, central to the axis, to the anode edge and hence a flat striking angle is inherent in the system. In this case, the protective plate then forms a surrounding ring, the width of which is greater than the width of the annular X-ray exit window, so that, on the one hand, the edge of the annular protective plate can be attached with good heat conduction to the vacuum housing near the anode-side edge of the X-ray exit window and, on the other hand, the other edge projects over the window in the direction of the cathode and thus effectively protects against striking of backscatter electrons.

Additional advantages, features and details of the invention are found in the following description of an exemplary embodiment, as well as with reference to the drawing, wherein:

**Fig. 1** shows a section through a rotary piston tube with a protective plate according to the invention placed in front of the X-ray exit window and

**Fig. 2,** an enlargement of the section II in **Fig. 1.**

The rotary piston tube, shown schematically, comprises a vacuum housing **3** provided in the vicinity of the cathode **1** with a constriction **2,** and an anode **4** connected stationary, like the cathode **1,** to the vacuum housing. In the region of the constriction **2** the vacuum housing **3** is surrounded by a magnetic system **5**, which serves to deflect and focus the electron beam **6**, which strikes the mostly beveled anode edge **7**. For protection of the annular X-ray exit window **8** from the backscatter electrons **9** heavily striking the anode edge **7** because of the flat striking angle of the electron beam **6**, according to the invention a protective plate **10** in the form of a ring of glass graphite is placed at some distance in front of the

X-ray exit window **8.** This annular protective plate is designed wider than the X-ray exit window **8** and with its anode-side end **11** is connected with good heat conduction to the vacuum housing **3**, while the cathode-side edge **12** is bent slightly inward, in order also to protect the cathode-side region of the vacuum housing **3** adjacent to the X-ray exit window from backscatter electrons.

The invention is not limited to the exemplary embodiment shown. In addition to the possibility, for example, of also using a protective plate according to the invention in rotary anode tubes for protection of the X-ray exit window, shaping and selection of material may be effected in some other way. What is crucial is only that the protective plate have good X-ray permeability, be capable of thermal loading and have good heat conduction and also have as small as possible an electron backscatter coefficient. In addition, it is important that good thermal contact should exist between the protective plate and the vacuum housing, in order to be able to remove the heat on the housing due to backscatter electrons, where especially in rotary piston tubes good heat removal to the surrounding medium is provided.

## Claims

1. X-ray tube having a magnetic system surrounding the vacuum housing with the cathode and the anode for deflection and focussing of the electron beam on the beveled anode edge, and an X-ray exit window located in the vacuum housing, **characterized in that** an X-ray-permeable protective plate (**10**) of a good heat-conducting material capable of thermal loading and having a small electron backscatter coefficient, which is in good thermal contact with the vacuum housing (**3**), is placed inside at some distance in front of the X-ray exit window (**8**).

2. X-ray tube according to Claim 1, characterized in that the protective plate (**10**) is connected with good heat conduction to the vacuum housing (**3**) on only one side at the cathode-side [*sic*] end (**11**).

3. X-ray tube according to Claim 2, characterized in that the protective plate (**10**) is bent inward at the free end (**12**) for the removal of backscatter electrons (**9**) from the vacuum housing (**3**).

4. X-ray tube according to any of Claims 1 to 3, characterized in that it is designed as a rotary piston tube with cathode (**1**) and anode (**4**) arranged stationary in a rotating vacuum housing (**3**) provided with an annular surrounding X-ray exit window (**8**), where the protective plate (**10**) forms a surrounding ring bent inward at the cathode-side edge (**12**).

5. X-ray tube according to any of Claims 1 to 4, characterized in that the protective plate (**8**) consists of beryllium.

6. X-ray tube according to any of Claims 1 to 4, characterized in that the protective plate (8) consists of glass graphite.

Accompanied by 1 page(s) of drawings